Microcomposite Fuel Cell Membranes

Foster Miller, Inc.

Oct '03

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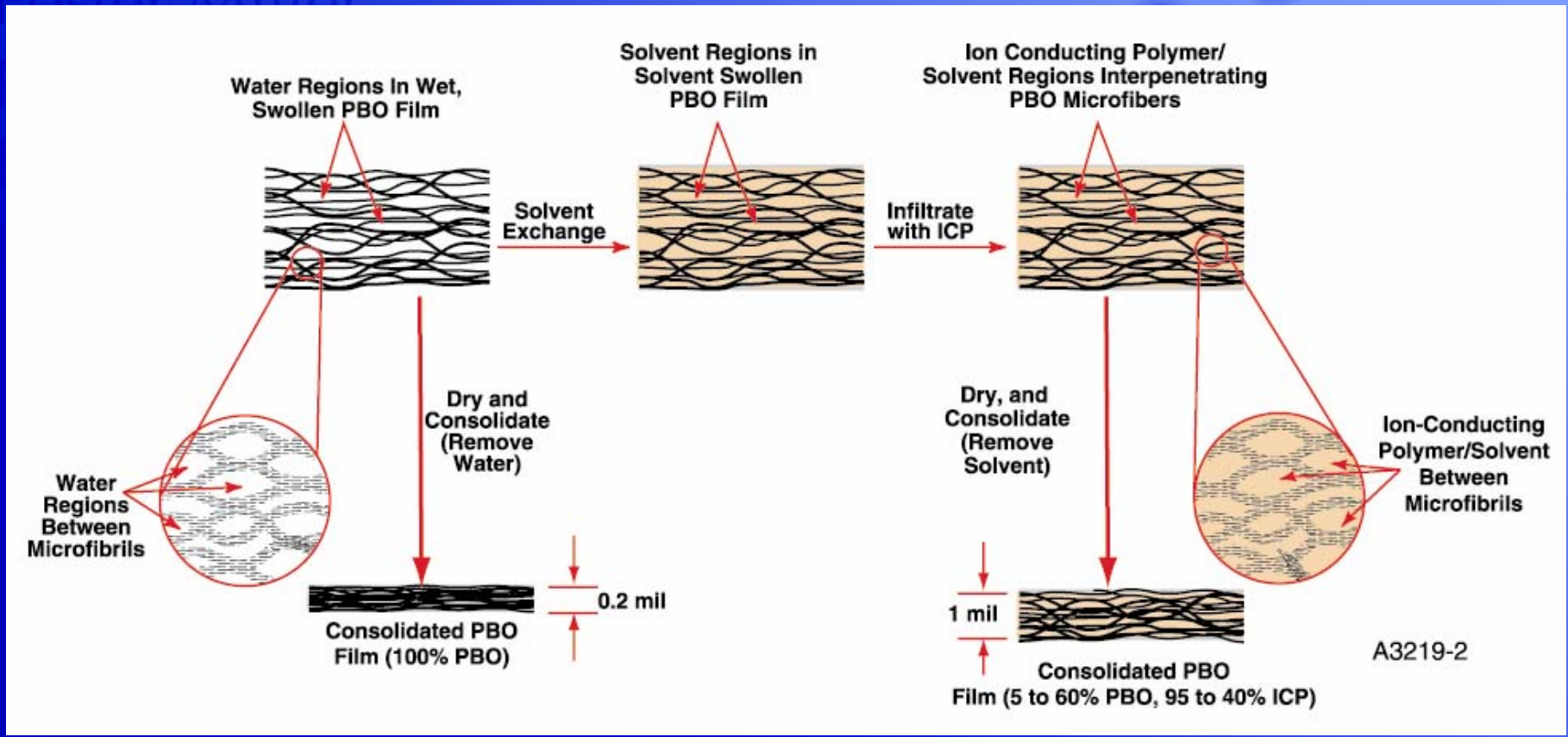
Foster-Miller Approach

FMI's patented microcomposite PEM separates the mechanical and electrical requirements of the membrane. High strength PBO is used to support highly conductive ICPs that lack the strength to stand alone

Fabricating a Microcomposite PEM

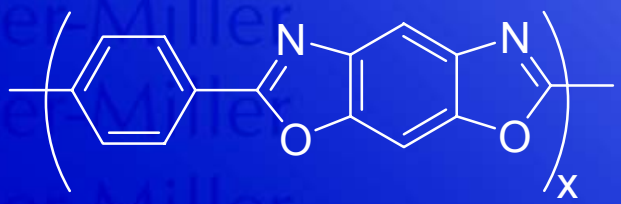


An ion-conducting polymer (ICP) is infiltrated into a swollen, mechanically strong poly(bisbenzoxazole) (PBO) substrate.

PBO Substrates

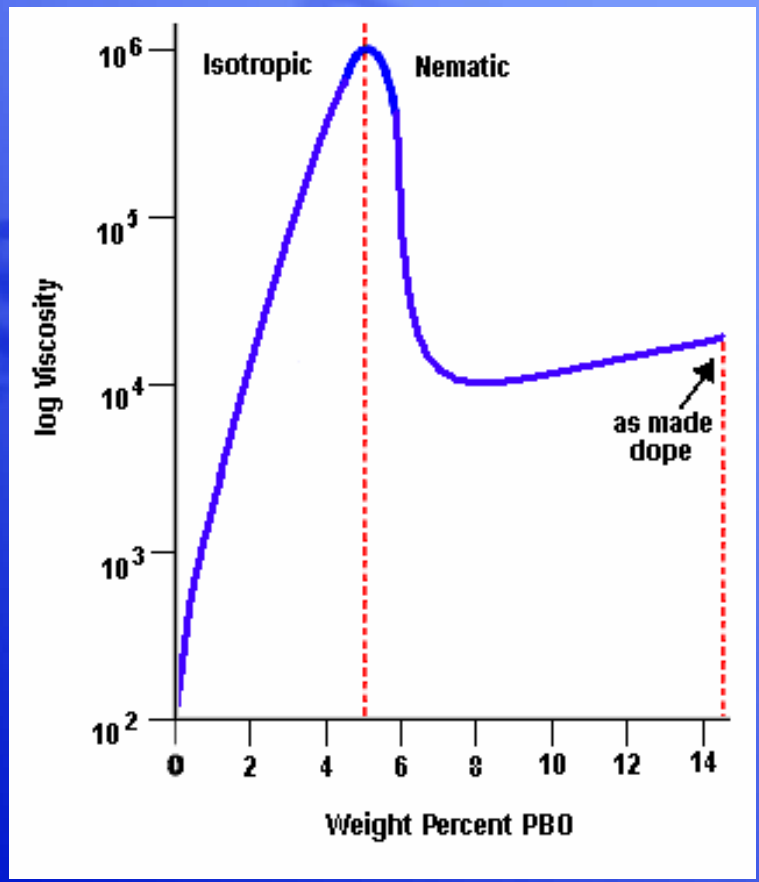
- Exceptionally high strength (100,000 psi)
- Superior dimensional stability (0% dimensional changes)
- Excellent chemical and thermal stability
- Outstanding barrier properties when fully consolidated.
- Processable into very thin films (0.2 to 1.0 mil thinness promotes decreased area specific resistance)
- Tailorable open structure accommodates varied ICP loadings
- **Consolidates upon drying to form fully densified composites with infiltrated ICPs.**

Phase Behavior of PBO Solutions

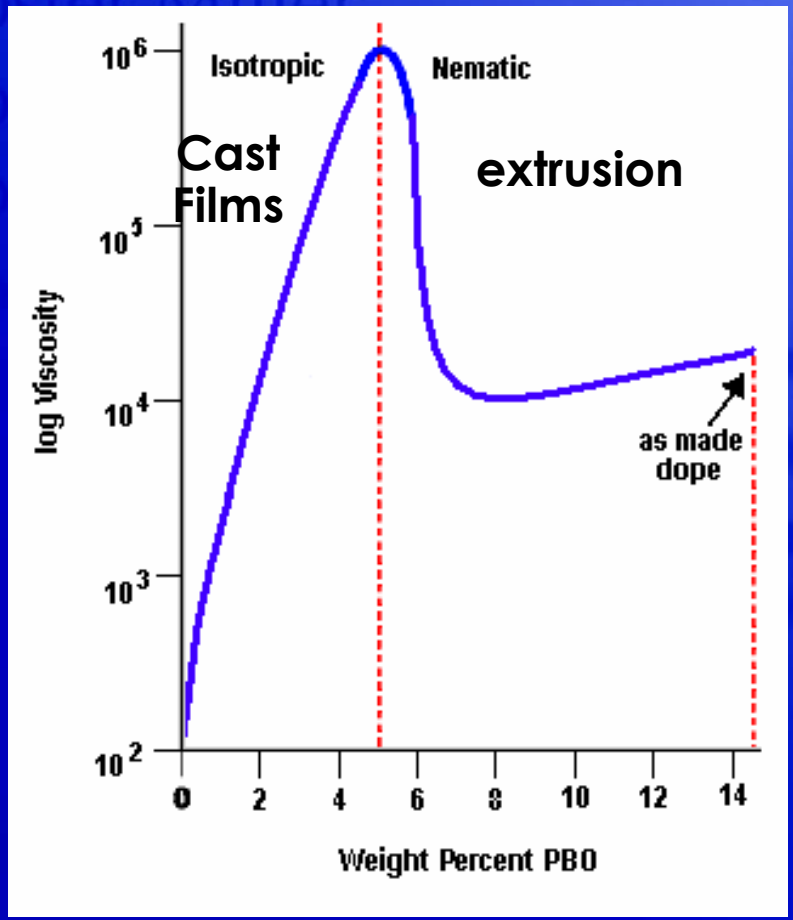


poly (bis benzoxazole)

- Lyotropic liquid crystalline polymer that is soluble in strong anhydrous acids
- Made in PPA and supplied in as-made solution



Substrate Processing

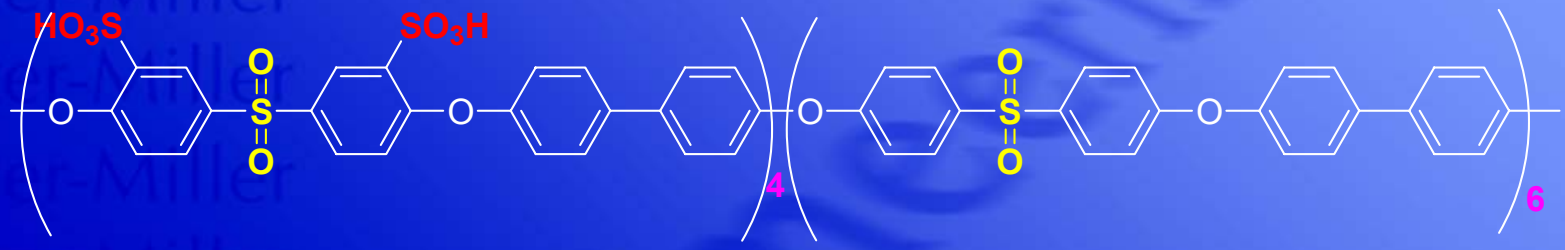


- PBO solution is shaped by extrusion or film casting.
- Coagulation in non-solvent (water) "locks in" structure of PBO.
- **Substrate void volume and pore size are defined by the concentration of the PBO solution.**

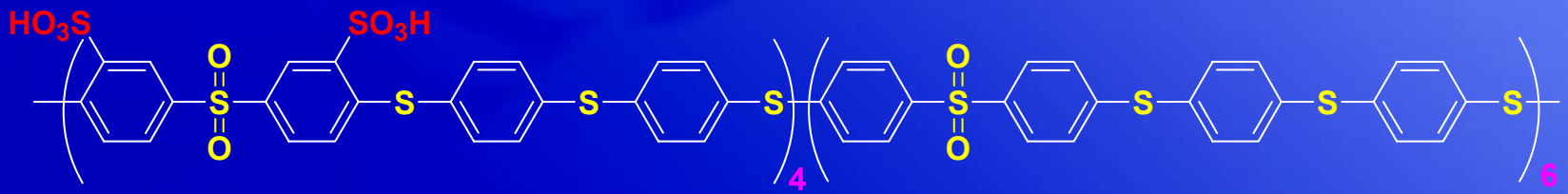
ICP Wish List

- Operates at high temperature (≥120°C) and low relative humidity (≤ 50% RH)
- Highly ion conductive
- Chemically stable
- Low cost (no fluorinated polymers)

Types of ICPs in FMI Microcomposite PEMs – Sulfonated Poly(sulfones)



SPES

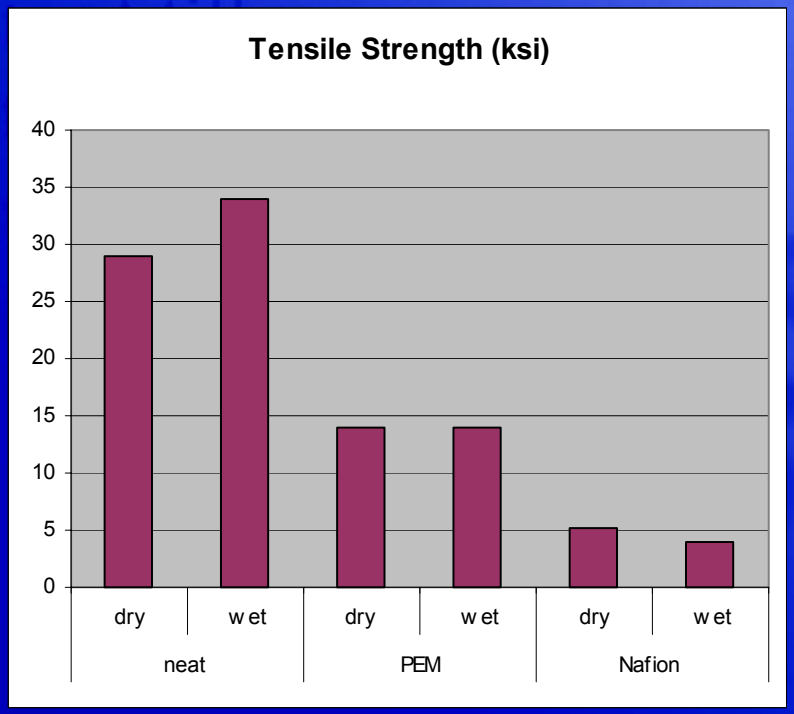


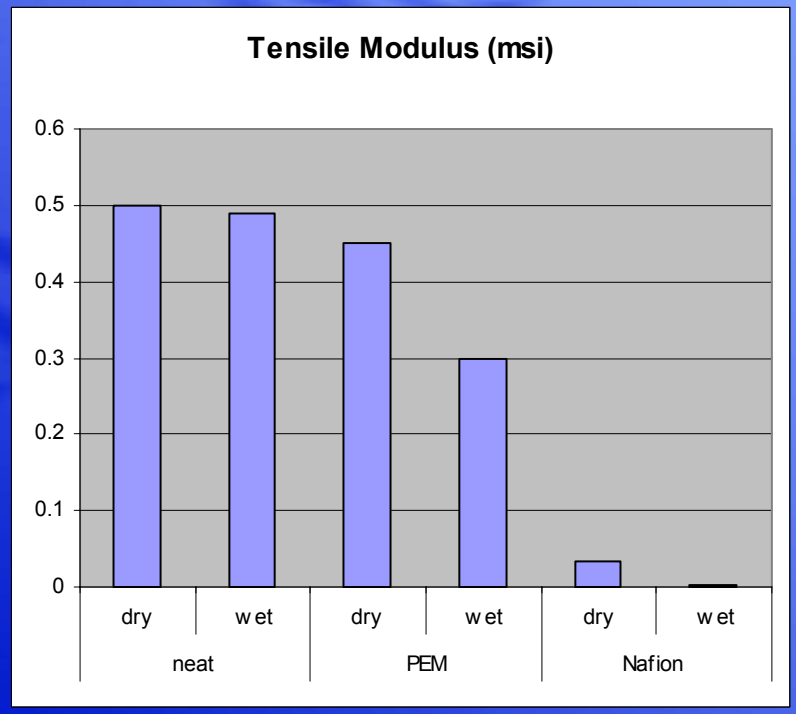
SPSS

Consolidation and Drying

- Thickness controlled by placing film in tension: all consolidation occurs in z-direction.
- Consolidation effected by drying at high temperatures (>200 C)

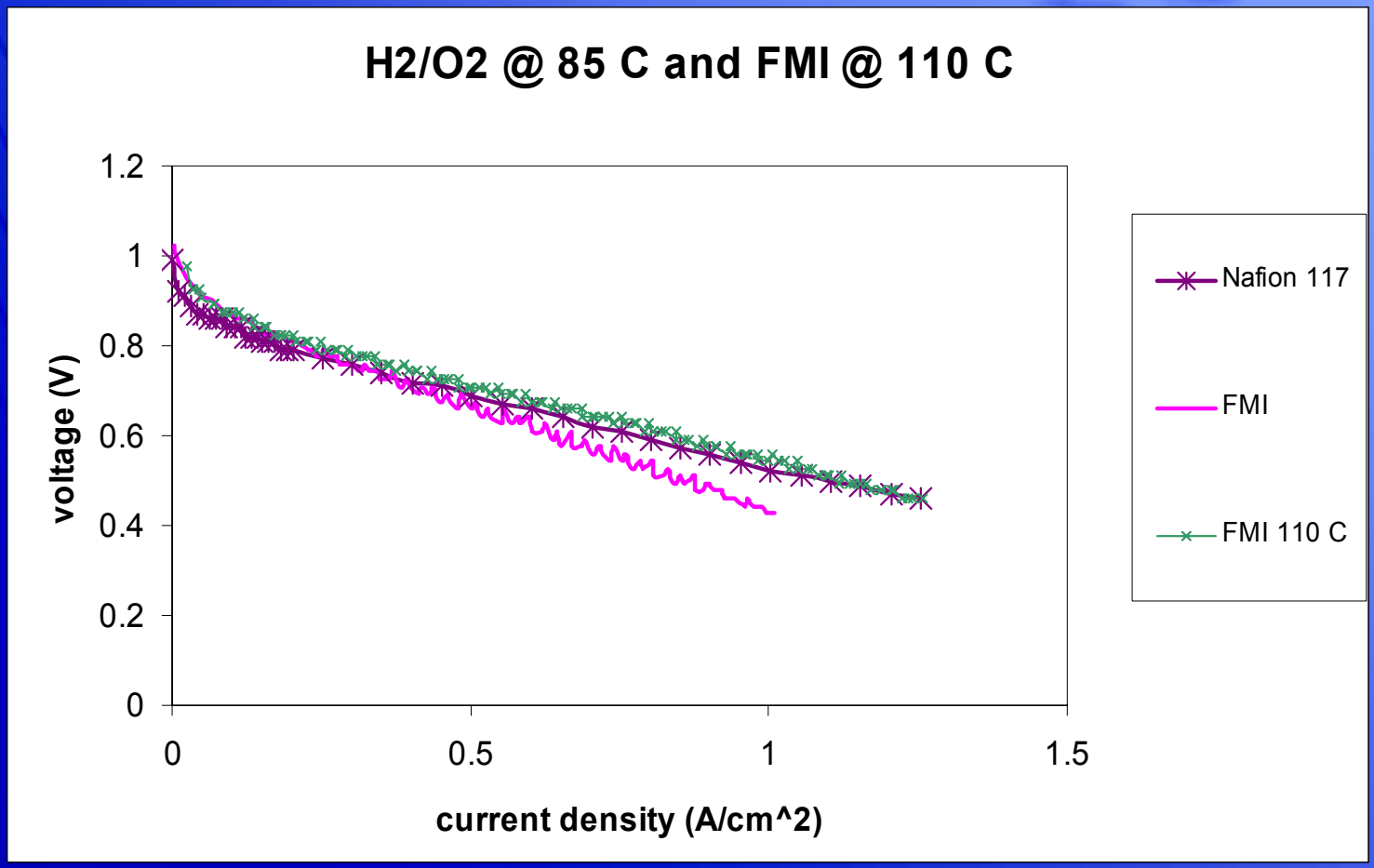
PEM Mechanicals (6.8% PBO)





Mechanicals of PEM significantly improved over Nafion (dry and wet)

MEA Performance



FMI's PBO/Acid Programs

- PBO/PA membranes
- Complexation and intimate mixing of ion conducting polymers and lyotropic liquid crystalline polymers

Sample Preparation

- Imbibing: Phosphonic acid ratios of two acid groups per available nitrogen on PBO. Ratios controlled by imbibing solution concentration and verified by elemental analysis
  - 7% PBO film imbibed with PA
  - 7% PBO film imbibed with poly(vinyl phosphonic acid)
- Co-mixing: Co-mixed solutions of PBO and poly(vinyl phosphonic acid) in MSA. Mixed solutions cast into film and coagulated in water. Resulting films have significantly lower PVPA fractions than above.

Conductivity of PBO/Acid Samples at 150°C

Variables

- Isotropic (1% from MSA) versus nematic (7% from PPA) PBO
- Ratio of PBO/acid groups
- Type of acid group: phosphonic acid? Sulfonic acid?
- Imbibed versus co-mixed solutions

In Progress…

- Currently comixing solutions of PBO/PPA and PSSA / PPA using a high shear mixture
  - Cast films for testing
  - Figure out coagulation conditions
- Testing and MEA fabrication on PBO/PA membranes to be performed by Jesse Wainwright (CWRU).